ON THE FACTORS ACTING UPON THE QUALITIES OF THE HUMUS CONTAINING LAYER OF NATURAL SOILS.

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The humus-containing layer of woodlands has been formed from decayed remains of plants mixed with minerals of the underlying soil. The humus-matters have been formed from different plants and parts of plants, to a considerable extent consisting of leaves of various trees. The decomposition process is considered to take place chiefly through microorganisms, which avail themselves of carbo-hydrates (sugar, starch, cellulose and hemi-cellulose), matters more resistant to decomposition, such as those belonging to the lignin-group, being left. In decomposing the carbo-hydrates the microorganisms synthesize nitrogenous complexes, proteins. After the decomposition of the plant residuous the decomposition product contains according the WAKSMAN (8) chiefly lignin matters (about 40 %) and nitrogenous complexes (about 30 %). The C/N ratio is then 10—12.

Depending on the soil and the condition of the undecomposed leaf fall and litter various forms of humus arise. If there is plenty of soluble bases in the soil and the litter decomposes easily, a saturated kind of humus (mull) arises. This form of humus generally occurs in leaf woods. This may also be due to the fact that in the leaf woods there are lignin-destroying fungi, Basidiomycetes, which again do not thrive in coniferous forests. The surface layer of the soil is further influenced by climatic factors contributing to the leaching of rather easily soluble matters. Thus it has been ascertained both in Sweden (S. Oden) and in Finland that of the woodlands about 50 tons of bases do leach within an area of one ha. Man, too, by his work (pasturage), influences the qualities of the soil. The growing capacity

of the soil has excited the interest of the scholars, who have considered the rocks and especially the limestone and basic rocks as very important in this respect. The researches, however made on this point are very few (7).

The reaction of the humus layer in coniferous forests and the mobilization of the nitrogen, the nitrification, has been examined by HESSELMAN (4) in Sweden. He has found that the humus of the leaf woods is less acid and that the nitrification takes place especially in close forests of rare leaf-trees and in alder woods, whereas in coniferous forests, with plenty of lichen, the nitrogen does not change into nitrate, only ammonia being formed. In mixed woods of pine and fir and rich in moss there is only a very faint nitrification to be observed.

In the following a preliminary attempt has been made to explain the influence of rocks, vegetation and pasturage on the qualities of the humus-containing layer.

As far as primary soils are concerned, the influence of the parent rock should be understood. But in Finland there are almost exclusively secondary, glacial soils, in which one might, therefore, possibly trace the influence of several rocks. As in all probability, the elements of the moraine have not covered long distances and their composition would rather reflect the influence of the parent rock, the present research has been confined so as to embrace chiefly the moraine

Table 1. Mechanical composition of moraine.

Locality	> 0.002	0.002–0.006	0.006–0.02	0.02–0.06	0.06–0.2	0.2–0.6	0.6–2.0	2.0–5.0	> 5.0
	mm.								
Paltamo, Mieslahti	—	0.24	0.36	1.19	13.07	33.42	7.91	5.49	38.32
Parish of Viipuri ..	—	2.02	3.85	14.53	16.07	10.65	10.12	13.93	28.83
Sääminki, Aholahti	—	3.28	5.86	13.65	27.07	16.06	8.19	14.77	11.14
Iisalmi, Iimäki	—	4.52	5.48	11.85	38.39	24.36	6.75	4.56	4.00
Sotkamo, Natula ..	—	5.05	14.25	20.44	17.27	12.77	8.39	9.44	12.39
Parish of Viipuri Terävälä	0.16	0.30	0.58	2.07	4.91	5.77	12.01	30,42	43.78
Kuhmoinen, Hahmaj.	1.98	1.38	3.41	8.13	13.23	7.76	5.95	8.12	50.04
Iimäki	3.18	6.04	6.57	9.43	31.65	14.58	6.10	4.36	18.09
Lohja, Varola	4.60	7.56	23.39	37.51	19.69	3.12	1.96	2.17	—
Lohja, Torhola	6.17	4.94	11.76	14.92	21.90	10.58	7.66	13.94	8.13
Viitasaari	7.09	8.12	12.79	17.51	31.69	13.06	6.01	3.73	—
Iisalmi, Ryhälänm.	9.82	4.65	8.90	12.33	31.34	14.34	5.74	3.67	9.21
Iisalmi, Haapajärvi	10.01	5.25	6,18	15.33	38.59	14.34	5.63	3.07	1.60

gravel occurring in different rock-districts. The moraine occurring in Finland is very coarse grained. It consists chiefly of sand, gravel and stones, and of some quantity of finer matters, as may be seen from the mechanical composition of the samples.

The moraine-specimens have been taken from different parts of the country. Their composition is most varying. In many specimens the finest matters (<0.002 mm) are lacking, of those belonging to the size-group of the clay there are none at all. There is very little silt, too. Such is, for instance, the sample taken from the top of Iimäki, on a height of about 200 m. above the level of the sea. The highest shore at Iimäki is 170 m. above the level of the sea (5). The place, from which the sample is taken, is then situated above the highest shore. The specimen belonging to the village of Haapajärvi in the parish of Iisalmi, on the other hand (Haapajärvi 86 m. above the level of the sea) contains at about 100 m. above the level of the sea plenty (10 %) of the finest matters (<0.002 mm). The moraine-grounds in the surroundings of Haapajärvi consists, to a greater part, of this kind of moraine. These moraine-grounds are below the highest shore. There are also plenty of fine matters from Ryhälänmäki, the highest point of which is 163 m. above the level ot the sea. In the neighbouring Kivimäki the highest shore is fixed at 170 m. above the sea-level. As a rule, the mechanic composition of the moraine is most varying, whether it be above or below the highest shore. The causes of the variability of the mechanical composition of the moraine are still entirely unexplained.

The samples have been collected from districts where the parent rock consists either of granite or gneiss, mica-schist, basic rocks (uralitporphy, uralit-plagioclase-porphyry, diabase, metabasite) and limestone. Of these rocks the granite covers 52.5 %, (rapakivi 6 %) the schists 9.1 %, the basic rocks 8.2 % and the limestone 0.08 % of the surface of Finland. They differ comparatively much as to their composition, especially as far as lime and potash are concerned, as is shown in the following table of averages.

Table 2.

	CaO %	MgO %	K_2O %	Na_2O %
Granite	1.44	2.02	4.46	3.24
Schists	2.47	1.82	3.80	2.66
Basic rocks	9.49	7.01	1.08	2.39

Mineral composition of rocks in Finland.

	Granite	Schists	Basic rocks
Quartz	26.8 %	29.9 %	6.7 %
Potash feldspar	22.4 %	—	0.9 %
Plagioclase (an < 30%)	38.0 %	16.1 %	—
» (an > 30%)	—	—	40.6 %
Mica	10.1 %	52.3 %	12.4 %
Hornblende and pyroxene	2.0 %	—	38.4 %
Apatite	0.2 %	1.0 %	0.3 %

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With regard to the feldspar it is to be noticed, that it chiefly consists of insoluble microcline, but in the rapakivi there is a considerable quantity of orthoclase.

As to their chemical composition the granite and the schist are like each other, the sum of the bases is almost the same. In the basic rocks there is an abundance of lime and magnesia. With regard to their mineralogical composition the granites contain, in addition to quartz, potash, feldspar and plagioclase rich in natron, and a small quantity of mica, the schists quartz, plagioclase rich in natron and plenty of mica and the basic rocks plagioclase rich in lime, hornblende or pyroxene and some mica.

If the rocks have influence upon the composition of the soil resting upon them, this ought to appear especially in the percentage of lime and magnesia. Likewise the moraine occurring in the basic rock districts ought to contain a greater quantity of heavy minerals.

In the examination of the heavy minerals the specific weight 2.68 has been taken for a limit. Among the most important rock-forming minerals, the specific weight of which is <2.68, are to be reckoned quartz, potash feldspar (mikrocline and orthoclase), natron-feldspar and plagioclases poor in lime (albite and oligoclase). To those exceeding a specific weight of 2.68 belong the plagioclases rich in lime (labradorite, bytownite and anorthite) calcite, muscovite, biotite, hornblende, apatite, chlorite, augite etc. Of the minerals influencing the fertility of the soil the most important are the plagioclases rich in lime, calcite, mica, chlorite, augite, apatite and olivine, most of which contain lime. The micas are important on account of their potash and the apatite on account of its phosphoric acid, and they are, in addition, comparatively easily soluble. They are, therefore, of considerable importance as soil-forming minerals. (6)

The sepration of the minerals has been made by using bromoform for the soil-fractions 0.6—0.2 mm and 0.2—0.06 mm.

Table 3. Heavy minerals in moraine spec. gravity > 2.68.

Locality	Heavy miner.	Mica		Locality	Heavy miner.	Mica	
Granite				*Micaschist*			
Viipurinp. Rapakivi	5.82	0.22	Horn-	Ristijärvi	1.45	0.05	
V.p. Terävälä »	39.90	4.40	blende	Ristij. Kontiomäki .	5.61	0.26	
Virolahti, Harju »	3.30	0.00		Paltamo, Mieslahti .	6.58	0.40	
Laitila »	3.71	0.63		Iimäki	4.45	0.32	
Renko granite	8.86	0.19		»	9.49	0.42	
Mustiala »	10.96	0.52		Kurkijoki	8.44	0.12	Chlo-
Sääminki »	3.09	0.26		Suistamo	63.70	0.03	rite
Jääski »	4.56	0.35		Jämsä	6.76	0.00	Plag.
Tammisto0–7 cm »	13.52	0.00		Kuhmoinen,Hahmaj.	26.41	6.00	22 %
» 25–30 cm »	7.82	0.12		Eräjärvi	8,71	0.02	
Turenki »	9.31	0.42		*Basic rocks*			
Mouhij.Selkee Micag.	7.58	0.82		Kisko 5—10 cm ..	9.15	0.02	
Otava „	7.61	0.77		» 20—30 cm ..	2.63	0.06	
Sauvo Gneissgr.	2.95	0.08		Tammela, Teuro ..	12.97	0.25	
Jorvas »	6.56	0.04		Ylivieska.....	13.92	0.09	
Iisalmi, Kurenp. »	5.95	0.11		Saloinen	5.92	0.00	
Ryhälänmäki »	6.60	0.23	Plag.	Jalovaara	17.20	0.15	
Harlu, Kirjaval. »	63.50	1.86	44.7 %	Sotkamo, Natula ..	6.13	0.71	Plag.
Lohja,Torhola Gneiss	7.31	1.09		Suistamo,Leppäsyrjä	22.16	0.02	15.7
				Kiiminki	51.71	0.00	

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In the examined moraine-fractions with a grain-size of 0.6—0.2 mm the percentage of minerals of a specific weight exceeding 2.68 is 1.4 — 14 %, but in some fractions more, as in the sample from the uralite-diabase-district of Jalovaara 17 %, Suistamo, Leppäsyrjä 22.2 (plagioclase 15.7 %), Kuhmoinen, Hahmajärvi 26.4 (plagioclase 22.2) from Terävälä in the parish of Viipuri 39.9 % (hornblende 35,8 and plagioclase 4.1 %), Kiiminki 51.7 % (8.1 plagioclase), Suistamo kk. 63.7 (55.5 chlorite) and Harlu, Kirjavalahti 63.5 % (44 % plagioclase). Of mica there is very little, as a rule under 1 %. It most frequently occurs in Lohja, Torhola 1.1 %, Kirjavalahti 1.86 % Viipuri, Terävälä 4.4 % and Kuhmoinen, Hahmajärvi 6.0 %.

In the grain group with the diameter 0.2—0.06 the frequency of heavier minerals is upon the whole the same as in the sand - fractions of medium coarseness. Yet it seems, as if the heavier minerals were

rather increasing in the finer fractions. This would suggest that the plagioclases and the dark minerals, micas, hornblende and pyroxenes would break more easily than potash-feldspar and quartz, which is very hard and without cleavage.

If we compare the quantities of heavier minerals in the moraine resting on the different rocks, we get aware that the samples taken from the granite and the mica-schist districts, when omitting those from the average value most differing, there is equally much of them, on an average 6.5 %. Exceptions are: in the rapakivi-district Terävälä, in the gneissgranite-district Kirjavalahti and in the mica-schist-districts Kuhmoinen and Suistamo. In the samples taken from the basic rock districts there is somewhat more heavy minerals, on an average 11 %.

Influence of the rocks and vegetation on the humus-containing surface-layer.

When comparing the average values obtained at the analysis of the samples taken from different rock-districts, one does not notice any considerable differences. The soluble and total nitrogen are all in the same size-group. Of soluble lime there is equally much in the soils from the granite and basic rock districts, in the schist-districts somewhat less. In the limestone district there is plenty of it. Of soluble potash there is more in the soils from the basic rock district as well as in the schist district. Of soluble phosphoric acid there is equally much in the granite and the basic rock district.

Table 4. The influence of rocks on the plant nutrients.

Humus layer.

	pH	Soluble mg/100 g				N mg/ 100 g	N % of hum.	Humus %
		N	CaO	K_2O	P_2O_5			
Granite	4.8	15.5	154	19.7	20.9	748	3.9	21.1
Basic rocks	4.6	17.3	159	31.6	21.0	754	2.9	29.8
Micaschist	4.4	15.6	101	23.3	13.0	641	4.6	16.0
Limestone	5.6	15.8	448	16.0	12.6	701	3.8	20.7
	Subsoil							
Granite	4,9	—	35	3.8	14			
Basic rocks	5.4	—	26	2.5	19			
Micaschist	4.6	—	20	3.5	13			
Limestone	7.5	—	334	2.9	15			

No regularity is to be noticed in the nitrogen percentage of the humus nor any relation between the latter and the soluble matters, the most nitrogenous humus being found in the specimens from the schist district, in which the humus contains on an average 4.6 % nitrogen, while that of the basic rock district is 2.9 % only. The reaction of the soil is on an average somewhat less acid in the granite district than in the basic rock and schist districts. In the limestone district the reaction is but faintly acid.

In comparing these numbers with the results of the subsoil analysis one will find the surface layer to be on the whole much richer in soluble matters than is the subsoil. Thus, in the humus-containing surface-layer there is 3—5 times more lime and 5—12times more potash. With regard to the phosphoric acid the difference is much less. It is, then, evident that the plants gather soluble matters, which remain in the surface layer. While relatively small quantities are withdrawn from the woodlands together with the trees, the litter brings instead each year to the surface of the soil rather much of easily soluble matters, the quantity of which in some degree depends on the vegetation.

Table 5. The chemical composition of undecomposed plant residues.

	Alder-leaf %	Birchleaf %	Spruce-needles %	Pine-needles %
Ashes.....	4.96	4.74	7.18	1.63
N	2.38	0.91	1.13	0.46
N (soluble)	0.19	0.14	0.11	0.06
Composition of ashes.				
SiO_2	19.99	21.39	63.94	14.22
Al_2O_3.....	2.82	11.57	3.16	11.19
Fe_2O_3.....	1.49	1.16	0.36	1.50
CaO	47.32	30.01	21.99	50.44
MgO	10.88	14.07	3.09	5.05
K_2O	7.92	10.48	2.19	5.12
Na_2O	1.37	1.16	1.27	3.34
P_2O_5	3.78	7.37	2.98	5.06
SO_3	3.94	2.55	0.95	4.03
Cl	0.49	0.24	0.07	—

Anal. A. Zilliacus, J. Raippalinna and H. Lönnroth.

Supposing that the quantity of litter supplied by the different kinds of trees is the same (according to the German scholars 3000

kg/ha), the litters would bring with them to the surface of the soil in the alder-woods 100 kg of bases, in the birch woods 80 kg, in the woods of spruce-fir 62 kg, and in the pine-woods 29 kg within an area of one ha. Lime is most richly supplied by the leaves of the alder about equally much by the leaves of the birch and the spruce-fir and relatively little by the needles of the pine. The leaves of the birch and the alder are rich in potash, and the leaves of the birch contain

Table 6. The chemical composition of plant recidues.

	Alderleaf kg/ha		Birchleaf kg/ha		Spruce-needles kg/ha		Pine-needles kg/ha	
Ashes.....	150		142		215		49	
N	71		27		34		14	
Composition of ashes								
CaO	70		43		47		24	
MgO	16		20		7		2	
K_2O	12	100	15	80	5	62	2	29
Na_2O.....	2		2		3		1	
P_2O_5	6		10		6		2	

the greatest quantity of phosphoric acid. The leaves of the alder also bring the greatest quantity of nitrogen, more than the double as compared with the birch-leaves. One might therefore suppose that this would appear also in the composition of the surface layer of the soil. For, as has been mentioned above, the leaves of the alder bring much greater quantities of lime than do those of other kinds of trees. The analyses show, however, that in the humus-containing layer of alder-woods there is less lime than in the woods of birch and spruce-fir. But in the grounds growing pine-wood there is less. This is also the case with regard to potash and phosphoric acid. Here it is to be

Table 7. The influence of vegetation on the humus-layer.

Tree vegetation	pH	Soluble mg/100 g				N mg/ 100 g	N % of humus	Humus %
		N	CaO	K_2O	P_2O_5			
Alder.....	4.4	15	132	18	14	803	4.6	18.5
Birch.....	5.0	14	162	15	18	647	4.0	16.9
Spruce	4.5	21	169	39	24	846	3.3	31.4
Pine	4.3	16	96	31	23	546	2.5	32.2

observed, that the surface layer of coniferous woods is richer in humus, for in them there is about the double of the quantity of humus as that occurring in the surface layer of leaf-woods. This is probably due to the fact that the fir-tree humus decomposes more slowly than does that formed from the leaf-tree litter. But no doubt there are other factors too. The leaf woods have on account of abundance of grass been real pastures and in this way considerable quantities of plant nutrients have surely been withdrawn. This will be clear from the examination of the results of the analysis of samples taken from old pastures. Such is the sample taken from a pasture in the neighbourhood of the church-village of Suistamo. The humus-containing layer is 12 cm or thicker than in the woodlands generally. The rock consists of micaschist and in the moraine there is plenty of heavy minerals (64 %) for the most part magnesia-containing chlorite, in which there is no lime at all. The vegetation consists of grass and hay growing alderwood. One might suppose the soil to be very rich in nutrients. It is, however, very poor, there being soluble lime and magnesia only nominally and very little potash and phosphoric acid too. The pasture lying on the grounds of the agricultural school of Kurkijoki is also very poor in plant nutrients. In the following samples (table 8) taken from pastures there is a somewhat greater quantity of soluble matters. But, for instance, in a sample taken from a grazing ground of the experiment station of Selkee, there is much less than is indicated by the average value for woodlands. And yet the soil consists of moraine mixed with clay and the vegetation is very rich (Alnus, Prunus padus, Populus, Betula, Sorbus, Lonicera, Ribes, Anemone, Oxalis, Paris, Ranunculus, Solidago, Rubus saxa-

Table 8. The influence of pasturage on the plant nutrients.

Locality	Heavy miner. %	Soluble mg/100 g				N mg/ 100 g	N % of humus
		N	CaO	K_2O	P_2O_5		
Suistamo	63.7	8	7	6	11	450	5.1
Kurkijoki	8.4	5	10	4	12	420	6.1
Selkee	7.6	10	52	13	17	450	5.7
Jalovaara	—	7	87	14	11	480	6.5
Iimäki	9.5	6	107	9	5	238	3.7
Sääminki	3.1	6	102	5	6	406	4.4
Jalovaara	17.2	5	63	7	11	270	4.1
Average		6.7	61.1	8.3	10.4	388	5.1
Average of forest soils		17	140	26	20	746	3.6

tilis, Aegopodium podagrarium, Viola, Hylocomium triquetrum, H. parietinum). In the samples taken from pastures the quantity of soluble matters corresponds on an average only to half of the average value indicated for the woodlands. As the soils of the pastures are, as a rule, not barren but, on the contrary, more fertile, this result cannot be accounted for but by supposing pasturage, during a very long time, in other words a sort of pillage. On the other hand, easily soluble plant-nutrients are not withdrawn in this way from the woodlands proper, except what is done in connection with the felling trees. Thence on the surface-layer of the woodlands proper matters accumulate, which the plant takes from deeper in the soil and drops together with the litters on the surface, where they are combined into organic compounds. According as these decompose the inorganic matters disengage.

As far as the woodland proper, from which the woodstuff only is utilized, is concerned, the following base quantities kg/ha are, on an average, withdrawn yearly, according to EBERMAYER (10):

Table 9.

	CaO	MgO	K_2O	Na_2O	Total of bases	P_2O_5
Birch	10.7	2.1	3.6	0.7	17.1	1.1
Spruce-fir	2.1	0.6	0.9	—	3.6	0.1
Pine	2.0	0.3	0.5	0.2	3.0	0.3

The quantities drawn out from the surface-layer are, thus, relatively small, particularly as compared with those which are brought to the surface of the soil together with the litters. In the pastures considerable quantities especially of potash are withdrawn together with the grass consumed by the cattle, depending on the growth of the grass fit for feed. The growth of trees on the pastures being generally rare, the surface layer does not receive even in this way soluble matters but very scantily.

This will be still more evident in the cultivated fields, in which easily soluble matters are, as a rule, very scanty in the culture layer in comparison with the surface layer of the woodlands, with the exception of phosphoric acid, which, on an average, occurs more richly in the fields. The quantity of plant nutrients in the cultivated fields depends of course on the manuring. But, as a rule, the uppermost or culture layer of cultivated fields is poorer in easily soluble matters than are the lower layers. This chiefly regards clay lands which have

Table 10. The influence of cultivation on the plant nutrients of the fields.

Locality	pH	Soluble mg/100 g				N mg/ 100 g	N % of humus
		N	CaO	K_2O	P_2O_5		
Loimaa, average							
Sand soil	5.6	6.4	—	5.5	21.8	387	4.5
Silty clay	5.6	4.8	—	7.6	29.6	266	4.7
Heavy clay	5.7	5.3	—	10.1	28.3	381	5.3
Salo I							
Heavy clay	5.6	4.8	148	8.8	24.6	428	6.7
Halola							
Sandsoil	5.5	3.2	133	4.2	46.0	224	5.9
Average pasture		6.7	61.1	8.3	10.4	388	5.1
Average forest soils		17	140	26	20	746	3.6

been under culture during a rather long time. In younger clay grounds this is not to be observed, but in their culture layer soluble matters may be more plentiful than in the subsurface and the subsoil. This shows that the percentage of easily soluble matters in the surface layer of the soil is influenced also by the leaching due to the climate. As a matter of fact, this phenomenon is to be observed especially in those clay lands, which have been during a rather long time under the influence of the climate. The leaching is to be observed particularly in the soil lying under the humus layer of natural sand-grounds, in which soil a layer very poor in soluble matters and known under the name of eluvial horizon has been formed. Thus, if one should examine the eluvial horizon layer and the subsoil in woodlands with regard to the quantity of plant nutrients, one would arrive at misleading results, because the quantity of plant nutrients of the humus-containing layer is very much greater, often multiple. This accounts for the remarkable growing capacity of virgin lands during the first years. But the humus-containing layer of the woodlands is generally very thin, often a few cm only, whence at the cultivation of useful plants, the quantities of plant nutrients do not suffice for a long time. This fact has previously been observed in practice. As early as in the time of clearance it was forbidden to take more than two crops from burn woodlands and to burn the same land anew, before the young forest grown up there had reached the age of thirty years in woods consisting chiefly of leaf-trees and forty years in woods chiefly consisting of pine and fir. The lack of nutriment seems to be one of the causes why the forest does not thrive well on cultivated ground, even

though this is also due to the change of the physical qualities of the soil and particularly as BURGER (3) has shown to the fact that the porosity of the soil has changed unfavourably.

SELOSTUS

LUONNONTILAISTEN MAIDEN HUMUSPITOISEN KERROKSEN OMINAISUUKSIIN VAIKUTTAVISTA SEIKOISTA.

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Tutkimuksessa tehdään selkoa kivilajien, kasvillisuuden ja laiduntamisen vaikutuksesta luonnontilaisten maiden kasvukerroksen ominaisuuksiin. Tutkimuksista käy selville, että moreenin hiekkafraktion mineraalikokoomus ei yleensä kuvaa allaolevan kalliopohjan kivilajeja. Siten on esim. kiilleliuskealueelta otetussa moreenissa hyvin vähän kiillettä, vaikka kiilleliuskeessa on n. 50 % kiillettä. Samoin vaikuttavat kivilajit yleensäkin verrattain vähän niiden päällä lepäävään moreeniin. Poikkeuksen tekee kalkkikivi, jonka vaikutus on tuntuva.

Metsämaiden humuspitoisessa kerroksessa on paljoa runsaammin kasvinravintoaineita kuin pohjamaassa, varsinkin liukoista kalkkia ja kalia moninkertaisesti. Fosforihappopitoisuudessa ei ole erikoisen suurta eroa.

Pitkäaikainen laiduntaminen kuluttaa pintakerroksen kasvinravintoaineita, niin että laidunmaiden kasvukerroksessa niitä on paljon vähemmän kuin metsämaiden. Ne muistuttavat tässä suhteessa peltojemme ruokamullan kasvinravintoainepitoisuutta.

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Appendix 1.

Locality of samples	Rocks	Soil	Tree vegetation	Depth cm	pH	From 100 g soil soluble mg N	CaO	MgO	K_2O	P_2O_5	Relat solub. % P_2O_5	Total P_2O_5 mg/100 g	C %	N mg/100 g	C/N	Humus %	N % of humus
Renko	granite	moraine	alder	0- 3	4.8	41	286	81	26	23	11	210	18.9	1540	12.3	32.6	4.7
Jääski	»	sand	»	0- 2	4.4	15	279	54	26	21	19	110	10.7	1060	10.1	18.5	5.7
Lohja, Torhola	gneiss	moraine	birch	0- 3	5.9	6	262	66	15	6	5	110	8.1	1120	19.3	13.8	3.0
Mustiala	hornblende gran.	»	spruce	0- 5	5.2	16	252	66	11	20	13	157	12.9	602	21.4	22.2	2.7
Kirjavalahti	gneiss-granite	»	alder	0-12	4.7	15	240	58	17	15	12	120	16.4	1160	14.1	28.4	4.1
Jääski	rapakivi	»	birch	0- 5	5.0	33	192	51	11	5	4	122	8.4	910	9.2	14.4	6.3
Mustiala	hornblende gran.	»	alder	0-10	4.9	12	188	44	19	15	10	151	9.8	756	12.8	16.7	4.5
Renko	granite	»	birch	0- 3	5.3	10	181	34	9	63	32	200	11.8	420	28.1	20.3	2.1
Parish of Viipuri, Saarela	rapakivi	»	spruce	0- 5	3.9	33	160	47	65	44	22	203	28.9	1190	24.3	49.9	2.4
Otava	micagneiss	»	birch	0- 7	5.5	11	148	34	13	24	18	130	4.7	360	13.1	8.1	4.4
Harju	rapakivi	moraine sand	pine	0- 3	3.5	36	139	37	60	44	55	80	38.0	1180	32.9	66.9	1.8
Tammisto	granite	moraine	spruce	0- 5	5.0	17	137	49	23	21	14	154	19.3	756	25.5	33.3	2.3
Mustiala	hornblende gran.	»	birch	0- 8	5.0	11	130	43	17	26	16	161	9.0	630	14.2	15.5	4.1
Tammisto	granite	»	hazel	0- 6	5.4	8	130	29	18	16	11	142	5.0	371	13.5	8.7	4.3
Turenki	»	sand	alder	0-12	4.6	10	127	24	4	14	16	90	6.8	590	11.5	11.7	5.0
Laitila	rapakivi	moraine	hazel	0- 5	5.6	12	123	6	10	27	11	250	8.5	798	10.7	14.6	5.4
Sauvo	gneiss-granite	sand	pine	0- 4	3.8	20	118	47	47	31	20	150	30.1	1330	22.6	52.0	2.5
Lohja, Varola	gneiss	moraine	hazel	0-15	4.9	7	114	35	12	4	4	108	6.9	476	14.4	12.0	4.0
Sääminki, Aholahti	granite	»	birch	0- 5	5.0	6	102	21	5	6	5	118	5.3	406	13.0	9.1	4.4
Kajaani, Mainua	»	»	alder	0- 3	4.0	15	69	15	12	8	11	70	7.6	504	15.0	13.1	3.9
Tammisto	»	»	birch-oak	0- 7	5.2	9	84	21	16	13	13	98	6.5	392	16.5	11.2	3.5
Mouhijärvi	micagneiss	»	alder	0-20	4.7	10	52	19	13	17	14	120	4.6	450	10.2	7.9	5.7
Otava	»	»	pine	0-20	5.0	4	28	7	5	17	17	100	3.0	210	14.3	5.2	4.0
Average					4.8	15.5	153.9	38.6	19.7	20.9	15.3	137.1	12.2	748	16.5	21.1	3.9
Kuhmoinen	micaschist	moraine	birch	0- 5	4.4	31	275	86	28	17	11	153	19.8	966	20.5	34.2	2.8
Suoniemi	»	»	spruce	0- 6	4.9	6	231	53	24	10	11	91	4.0	434	9.3	7.0	6.2
Ristijärvi	»	»	»	0- 5	4.0	37	144	56	77	32	22	145	24.2	938	25.9	41.8	2.2
Iisalmi, Iimäki	»	»	birch	0- 5	4.8	6	107	22	9	5	5	93	3.7	238	15.7	6.5	3.7
Eräjärvi	»	»	spruce	0- 5	4.0	28	101	61	42	17	13	134	8.8	763	11.5	15.2	5.0
Ristijärvi	»	»	alder	0- 5	4.6	15	97	17	17	5	5	93	9.5	658	14.4	16.4	4.0
Suoniemi	»	»	birch. asp.	0- 5	5.1	14	97	45	9	17	11	145	6.3	644	9.8	10.9	5.9
Jämsä	»	»	alder	0- 5	3.6	20	81	55	47	8	8	103	8.8	966	9.1	15.1	6.4
Kurkijoki	»	»	»	0-20	3.6	13	56	11	12	17	13	130	14.3	1050	13.7	24.8	4.2
Suistamo	»	sand	pine	0-20	5.1	4	11	4	5	8	16	50	2.0	170	16.8	4.9	3.5
Kurkijoki	»	moraine	spruce	0-20	4.2	5	10	4	4	12	13	90	4.0	420	9.5	6.9	6.1
Suistamo	»	»	alder	0-12	4.6	8	7	5	6	11	12	90	5.1	450	11.5	8.8	5.1
Average					4.4	15.6	101.4	34.9	23.3	13.3	11.7	109.8	9.3	641.4	14.0	16.0	4.6
	Basic rocks																
Saloinen	diabase	moraine	spruce	0- 4	4.6	28	289	115	72	32	15	220	28.9	1550	18.6	50.0	3.1
Paltamo, Mieslahti	metabasite	»	birch	0- 5	4.4	21	269	70	21	15	13	133	16.9	854	19.8	28.3	3.0
Tammela, Tenno	ural.-porph.	»	spruce	0- 4	4.8	10	254	41	51	28	23	120	25.9	910	28.5	44.7	2.0
Paltamo	metabasite	»	»	0- 5	4.5	21	197	179	37	18	12	145	24.9	868	28.7	43.0	2.0
Ylivieska	ural. plagiocl. porph.	»	birch alder pine	0- 4	4.0	21	168	50	30	21	16	130	23.1	990	23.3	39.8	2.5
Ylivieska	»	»	»	0- 4	3.9	28	165	48	51	33	17	200	23.2	1150	20.2	40.1	2.8
Jalovaara	ural. diabase	moraine sand	»	0- 3	4.4	12	143	30	30	18	20	90	13.2	420	31.4	22.7	1.8
Kisko	leptit. a. amphib.	moraine	birch	0- 5	5.1	11	118	31	15	17	24	70	5.6	320	17.5	9.7	3.3
Jalovaara	ural. diabase	moraine sand	»	0- 7	5.4	7	87	17	14	11	16	70	4.3	480	8.9	7.4	6.5
Kisko	leptit. a. amphib.	»	spruce	0- 5	4.0	33	80	36	29	36	19	190	18.4	880	20.9	31.7	2.8
Tammela	ural. porph.	sand	pine	0- 5	4.4	11	71	17	22	13	17	80	19.3	360	53.1	33.4	1.1
Jalovaara	ural. diabase	moraine sand	alder	0- 5	5.4	5	63	15	7	11	14	80	3.8	270	14.1	6.6	4.1
Average					4.6	17.3	158.6	54.1	31.6	21	17.1	127.3	17.3	754.3	23.8	29.8	2.9
Pälkjärvi, Ulaanvaara	limestone	moraine	alder	0-30	6.9	11	910	11	9	10	9	110	14	980	14.3	23.3	4.2
Suistamo, Leppäsvrjä	»	»	birch	0-10	6.8	10	539	118	3	8	7	110	6	580	9.7	9.7	6.0
Kiiminki	»	»	spruce	0-15	5.0	15	269	111	20	8	7	110	14	460	29.4	23.4	1.9
Sotkamo, Natula	»	»	»	0- 3	3.8	27	73	18	32	25	17	150	15	784	19.5	26.5	2.9
Average					5.6	15.8	447.7	64.5	16	12.6	10.0	120	12.3	701	18.2	20.7	3.8

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Appendix 2.

Locality of samples	Rocks	Soil	Tree vegetation	pH	From 100 g soil soluble mg					Relat. solubility	P_2O_5 mg/100 g	Total		C/N	Humus %	N % of humus
					N	CaO	MgO	K_2O	P_2O_5			C %	N mg/100 g			
Renko	granite	moraine	alder	4.8	41	286	81	26	23	11	210	18.9	1540	12.3	32.6	4.7
Jääski	»	sand	»	4.4	15	279	54	26	21	19	110	10.7	1060	10.1	18.5	5.7
Kirjavalahti	gneiss-granite	moraine	»	4.7	15	240	58	17	15	12	120	16.4	1160	14.1	28.4	4.1
Mustiala	hornblende gran.	»	»	4.9	12	188	44	19	15	10	151	9.7	756	12.8	16.7	4.5
Turenki	granite	sand	»	4.6	10	127	24	4	14	16	90	6.8	590	11.5	11.7	5.0
Kajaani, Mainua	»	moraine	»	4.0	15	69	15	12	8	11	70	7.6	504	15.0	13.1	3.9
Mouhijärvi	micagneiss	»	»	4.7	10	52	19	13	17	14	120	4.6	450	10.2	7.9	5.7
Ristijärvi	micaschist	»	»	4.6	15	97	17	17	5	5	93	9.5	658	14.4	16.4	4.0
Jämsä	»	»	»	3.6	20	81	55	47	8	8	103	8.8	966	9.1	15.1	6.4
Kurkijoki	»	»	»	3.6	13	56	11	12	17	13	130	14.3	1050	13.7	24.8	4.2
Suistamo	»	»	»	4.6	8	7	5	6	11	12	90	5.1	450	11.5	8.8	5.1
Ylivieska	ural.-plag. porph	»	»	4.0	21	168	50	30	21	16	130	23.1	990	23.3	39.8	2.5
Jalovaara	ural.-diabase	moraine sand	»	5.4	5	63	15	7	11	14	80	3.8	270	14.1	6.6	4.1
Average				4.4	15.4	131.8	34.5	18.2	14.3	12.4	115.2	10.7	803.3	13.2	18.5	4.6
Parish of Hels., Tammisto	granite	moraine	hazel	5.4	8	130	29	18	16	11	142	5.0	371	13.5	8.7	4.3
Laitila	rapakivi	»	»	5.6	12	123	6	10	27	11	250	8.5	798	10.7	14.6	5.4
Lohja, Värola	gneiss	»	»	4.9	7	114	35	12	4	4	108	6.9	476	14.4	12.0	4.0
Average				5.3	9	122.3	23.3	13.3	15.7	8.7	166.6	6.8	548.3	12.9	11.8	4.6
Lohja, Torhola	gneiss	moraine	birch	5.9	6	262	66	15	6	5	110	8.1	1120	19.3	13.8	3.0
Jääski	rapakivi	»	»	5.0	33	192	51	11	5	4	122	8.4	910	9.2	14.4	6.3
Renko	granite	»	»	5.3	10	181	34	9	63	32	200	11.8	420	28.1	20.3	2.1
Otava	micagneiss	»	»	5.5	11	148	34	13	24	18	130	4.7	360	13.1	8.1	4.4
Mustiala	hornblende gran.	»	»	5.0	11	130	43	17	26	16	161	9.0	630	14.2	15.5	4.1
Sääminki, Aholahti	granite	»	»	5.0	6	102	21	5	6	5	118	5.3	406	13.0	9.1	4.4
Parish of Hels., Tammisto	»	»	»	5.2	9	84	21	16	13	13	98	6.5	392	16.5	11.2	3.5
Kuhmoinen	micaschist	»	»	4.4	31	275	86	28	17	11	153	19.8	966	20.5	34.2	2.8
Iisalmi, Iimäki	»	»	»	4.8	6	107	22	9	5	5	93	3.7	238	15.7	6.5	3.7
Suoniemi	»	»	»	5.1	14	97	45	9	17	11	145	6.3	644	9.3	10.9	5.9
Ylivieska	ural.-plag. porph.	»	»	4.0	21	168	50	30	21	16	130	23.1	990	23.3	39.8	2.5
Paltamo, Mieslahti	metabasite	»	»	4.4	21	269	70	21	15	13	133	16.9	854	19.8	28.3	3.0
Kisko	leptit-amphib.	moraine sand	»	5.4	7	87	17	14	11	16	70	4.3	480	8.9	7.4	6.5
Average				5.0	14.3	161.7	43.1	15.2	17.6	12.7	127.9	9.8	646.9	16.2	16.9	4.0
Mustiala	hornblende gran.	moraine	spruce	5.2	16	252	66	11	20	13	157	12.9	602	21.4	22.2	2.7
Viipuri, Saarela	rapakivi	»	»	3.9	33	160	47	65	44	22	203	28.9	1190	24.3	49.9	2.4
Parish of Hels., Tammisto	granite	»	»	5.0	17	137	49	23	21	14	154	19.3	756	25.5	33.3	2.3
Suoniemi	micaschist	»	»	4.9	6	231	53	24	10	11	91	4.0	434	9.3	7.0	6.2
Ristijärvi	»	»	»	4.0	37	144	56	77	32	22	145	24.2	938	25.9	41.8	2.2
Eräjärvi	»	»	»	4.0	28	101	61	42	17	13	134	8.8	763	11.5	15.2	5.0
Kurkijoki	»	»	»	4.2	5	10	4	4	12	13	90	4.0	420	9.5	6.9	6.1
Saloinen	diabase	»	»	4.6	28	289	115	72	32	15	220	28.9	1550	18.6	50.0	3.1
Tammela, Teuro	ural. porph.	»	»	4.8	10	254	41	51	28	23	120	25.9	910	28.5	44.7	2.0
Paltamo	metabasite	»	»	4.5	21	197	179	37	18	12	145	24.9	868	28.7	43.0	2.0
Kisko	leptit amphib	moraine sand	»	4.0	33	80	36	29	36	19	190	18.4	880	20.9	31.7	2.8
Average				4.5	21.3	168.6	64.3	39.5	24.5	16.1	149.9	18.2	846.5	20.4	31.4	3.3
Harju	rapakivi	moraine sand	pine	3.5	36	139	37	60	44	55	80	38.0	1180	32.9	66.9	1.8
Sauvo	gneiss granite	sand	»	3.8	20	118	47	47	31	20	150	30.1	1330	22.9	52.0	2.5
Otava	micagneis	moraine	»	5.0	4	28	7	5	17	17	100	3.0	210	14.3	5.2	4.0
Suistamo	micaschist	sand	»	5.1	4	11	4	5	8	16	50	2.0	170	16.8	4.9	3.5
Tammela, Susikas	ural. porph.	»	»	4.4	11	71	17	22	13	17	80	19.3	360	53.1	33.4	1.1
Ylivieska	ural.-plag. porph.	moraine	»	3.9	28	165	48	51	33	17	200	23.2	1150	20.2	40.1	2.8
Jalovaara	ural. diabase	moraine sand	»	4.4	12	143	30	30	18	20	90	13.2	420	31.4	22.7	1.8
Average				4.3	16.4	96.4	27.1	31.4	23.4	23.1	107.1	18.4	545.7	27.4	32.2	2.5

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Appendix 3.

Average.

Rocks	Tree vegetation	pH	Soluble mg from 100 g soil					Relat. solub. % P_2O_5	Total			C/N	Humus %	N % of humus
			N	CaO	MgO	K_2O	P_2O_5		P_2O_5 mg/100 g	C %	N mg/100 g			
Granite and gneiss ..		4.8	15.5	154	39	20	21	15	137	12.2	748	16.5	21.1	3.9
Micaschist		4.4	15.6	101	35	23	13	12	110	9.3	641	14.0	16.0	4.6
Basic rocks		4.6	17.3	159	54	32	21	17	127	17.3	754	23.8	29.8	2.9
Limestone		5.6	15.8	448	64	16	13	10	120	12.2	701	18.2	20.7	3.8
	Alder	4.4	15	132	34	18	14	12	115	10.7	803	13.2	18.5	4.6
	Hazel	5.3	9	122	23	13	16	9	167	6.8	548	12.9	11.8	4.6
	Birch	5.0	14	162	43	15	18	13	128	9.8	647	16.2	16.9	4.0
	Spruce	4.5	21	169	64	39	24	16	150	18.2	846	20.4	31.4	3.3
	Pine	4.3	16	96	27	31	23	23	107	18.4	546	27.4	32.2	2.5